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6. AUTHORS George Stegeman, PI (Univ. of Central Florida); Greg Salamo, Co-PI (Univ. of Arkansas)			
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11. SUPPLEMENTARY NOTES

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12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution unlimited.	12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

The focus of this work is to demonstrate discrete solitons in arrays of coupled nonlinear waveguides or the controlled switching of optical information from one line to another. Results have been the successful creation of a linear array of over one hundred soliton waveguides. The array is necessary to demonstrate transfer of energy across the soliton array. The significance or impact is that this project is the first step to achieve photonic networks using discrete solitons-all-optical routers. It is possible to use the discrete soliton arrays to switch optical information from one channel to another, using only optical beams. For this reason, the results demonstrate discrete solitons and their potential use in optical communication systems.

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TO: U.S. Army Research Office

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P.O. Box 12211

Research Triangle Park, NC 27709-2211

FROM: Professor Greg Salamo

Physics Department

University of Arkansas

Fayetteville, AR 72701

<p style="text-align:center">FINAL REPORT: ARRAYS TO SUPPORT SPATIAL SOLITONS
DOD - MURI FELLOWSHIP-A04678
April 2, 2000 to April 1, 2004</p>

ABSTRACT

The focus of this work is to demonstrate discrete solitons in arrays of coupled nonlinear waveguides or the controlled switching of optical information from one line to another. Results have been the successful creation of a linear array of over one hundred soliton waveguides. The array is necessary to demonstrate transfer of energy across the soliton array. The significance or impact is that this project is the first step to achieve photonic networks using discrete solitons-all-optical routers. It is possible to use the discrete soliton arrays to switch optical information from one channel to another, using only optical beams. For this reason, the results demonstrate discrete solitons and their potential use in optical communication systems.

ARRAYS TO SUPPORT SPATIAL SOLITONS

I. STATEMENT OF THE PROBLEM STUDIED

Route information is among the most important functions of a photonic network. In such optical systems it is often highly desirable that routing is accomplished all-optically so as to avoid unnecessary electro-optic conversion. If for example data is re-directed by a space-switching matrix, it is also crucial that this process occurs with minimum diffraction induced cross-talk or losses among nodes. The photorefractive nonlinearity offers a promising solution to this problem since, under appropriate conditions, is known to balance diffraction effects. In fact, in nonlinear waveguide arrays a self-trapped entity is possible, better known as a discrete soliton (DS). By their very nature, discrete solitons represent collective excitations of a periodic lattice as a whole and produce a balance between the photorefractive nonlinearity and discrete diffraction effects. Optical DS were successfully observed in nonlinear AlGaAs waveguide arrays. However, this requires high intensities while photorefractives can operate at very low powers.

Recently our MURI team has shown that DS in two-dimensional nonlinear waveguide array networks can provide a rich environment for all-optical data processing applications. More specifically we have demonstrated that this family of solitons can be employed to realize routing, blocking, logic functions, time-gating etc. In principle, DS can be navigated anywhere in the network and act like optical wires. Even more importantly, DS can be routed at array intersections and behave as DS switching junctions.

As an example, consider light in an array that propagates along the z-axis and is confined in the transverse x-y plane. This represents a discrete soliton set in motion. This is done by appropriately chirping (spatially) or tilting the soliton beam with respect to the z-axis. In order to investigate the effects of bends on the behavior of DS, our team has numerically simulated the process. Interestingly enough the DS can successfully negotiate a sequence of bends with very little radiation/reflection losses. These losses can be accurately predicted from coupled mode

theory and can be effectively minimized by engineering the corner of the bend. In such a case, the bending losses are expected below 0.5% after a 90° bend.

The effort of the MURI Fellow has evolved over the time of the grant into developing a clear demonstration of this concept

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II. SUMMARY OF THE MOST IMPORTANT RESULTS
### 1-D Discrete Diffraction and Modulation Instability

We examined a linear fixed array shown below. The array was excited by a probe beam of longer wavelength to demonstrate discrete diffraction. We are now observing a clear observation of modulation instability MI in this 1D lattice. This effort has required us to develop a clear understanding of the effect of the incident beam of a fixed lattice. In addition, we have also uncovered the role of the background uniform beam on the waveguide and the comparison with MI. The application of an applied field also shows trapping as a function of applied voltage or optical intensity
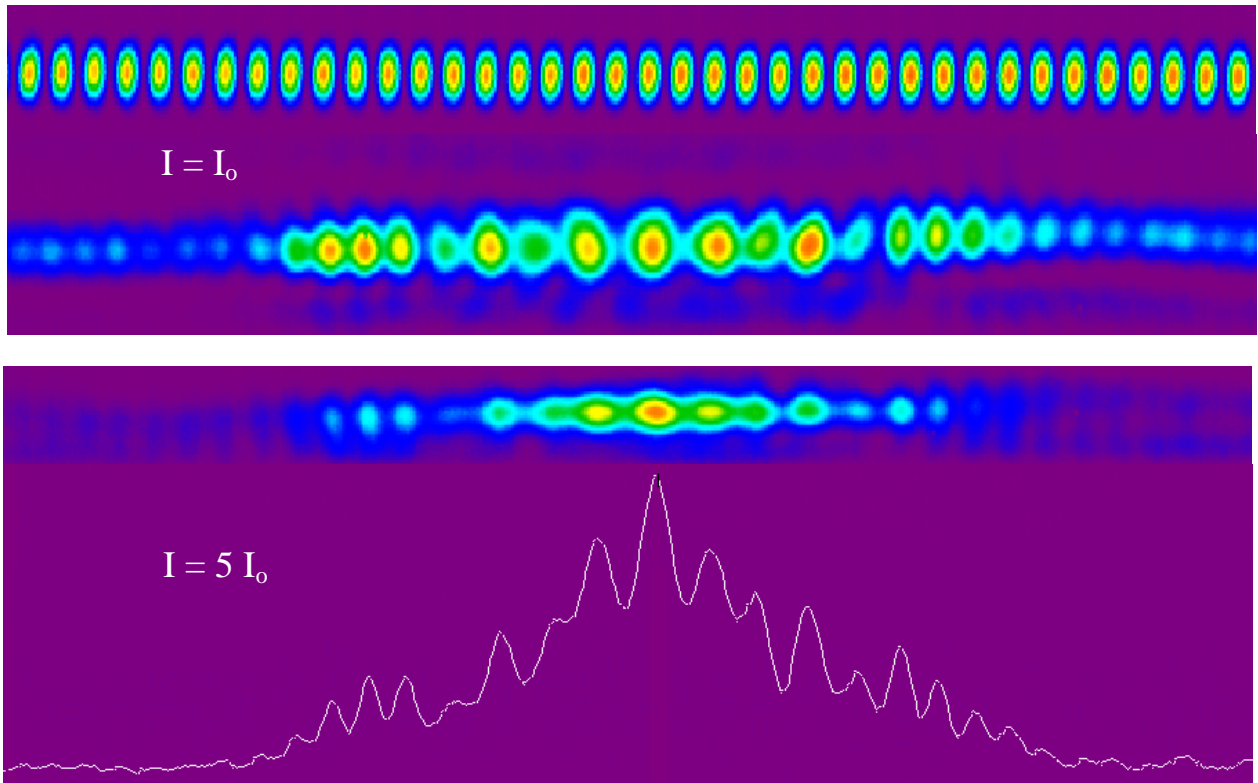
1-D Transverse Instability

We have recently observed a new type of transverse instability. As in the previous case we use two laser beams that are focused with cylindrical lens to produce an interference pattern at the entrance face of the crystal (2a). This interference array diffracts by the time it reaches the exit face (2b). By applying a dc electric field solitons are formed in the crystal and the output beam diameter reduces to the input beam diameter (2c). Figures 2(d-h) show transverse instability as

Input Array of Optical Beams (2a)
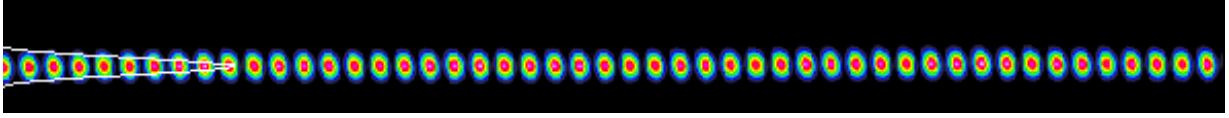
Output Array after 5 Minutes (2b)
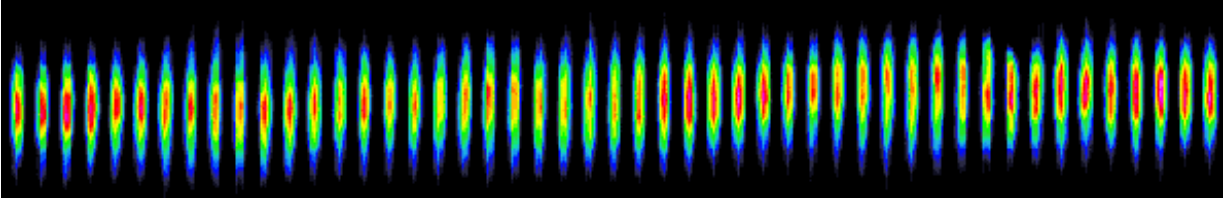
Output Soliton Array after 15 minutes (2c)
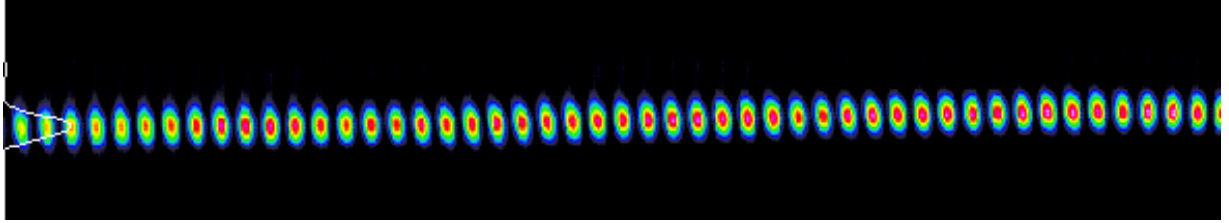
Output Array after 20 minutes (2d)
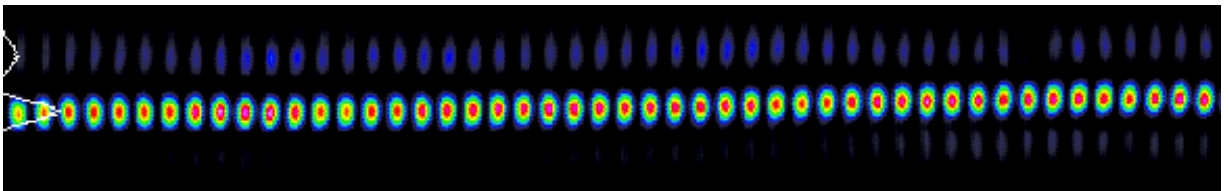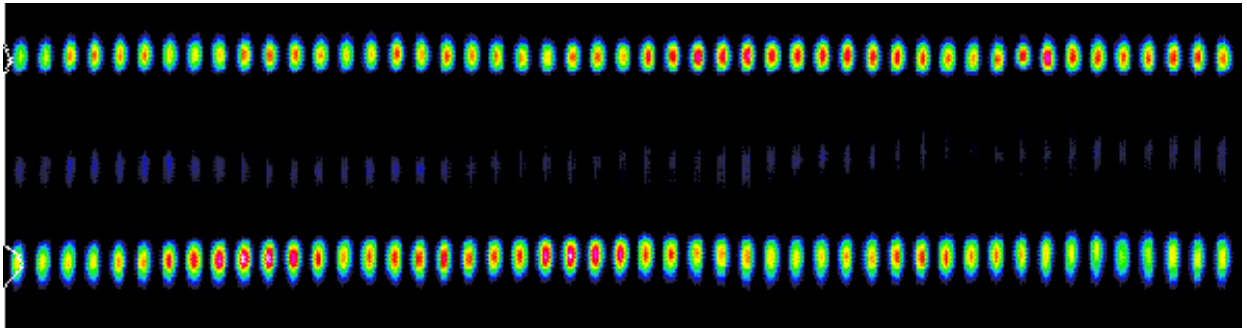

Output Array after 25 minutes (2e)
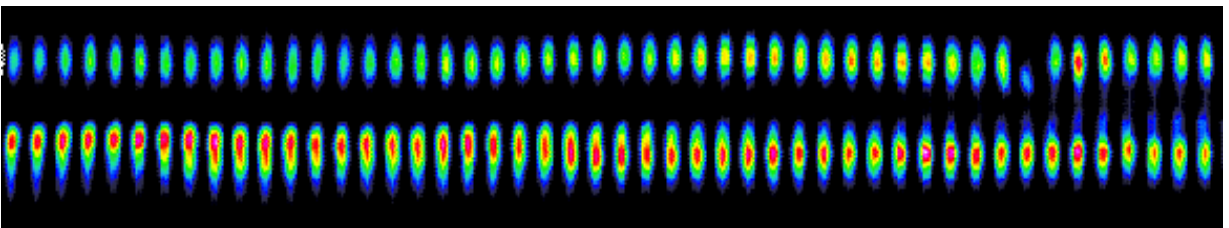
the 1-D array splits into two arrays and a trance of a third array. Interference between the 1-D arrays and a reference beam show a 180 degree phase shift between the outer arrays (2i).
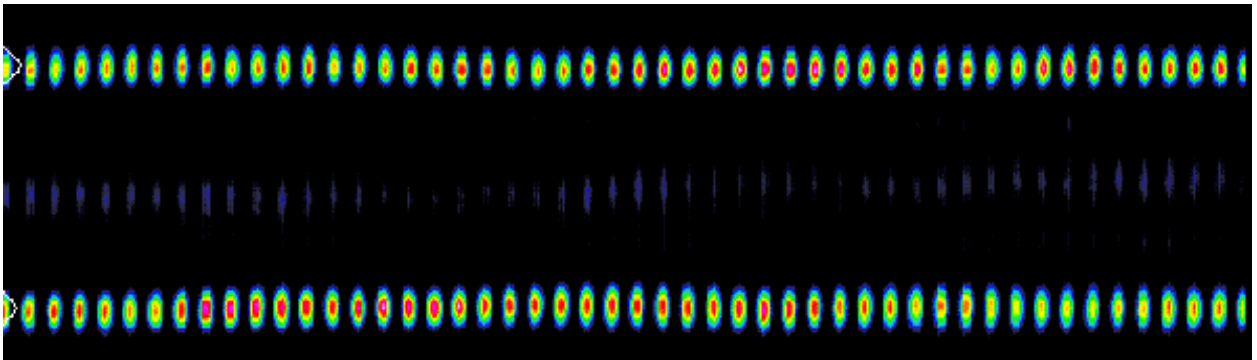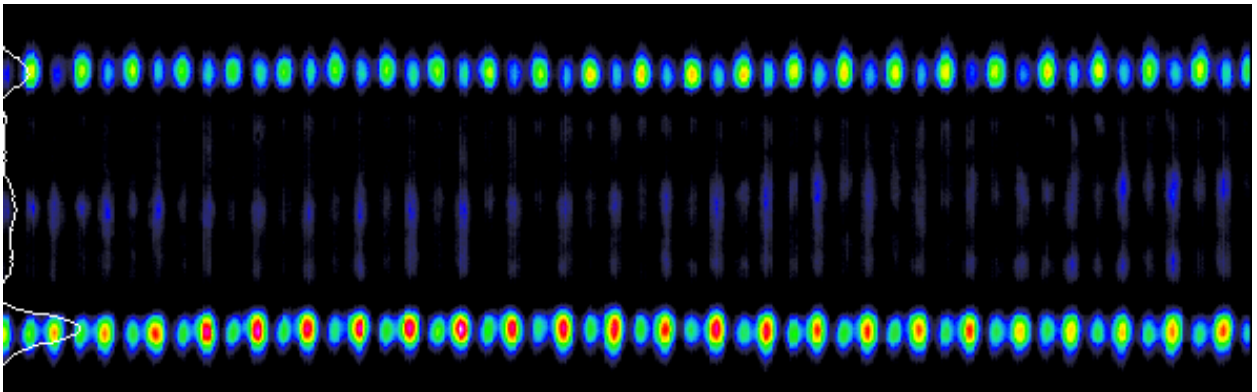
Output Array after 40 minutes (2f)
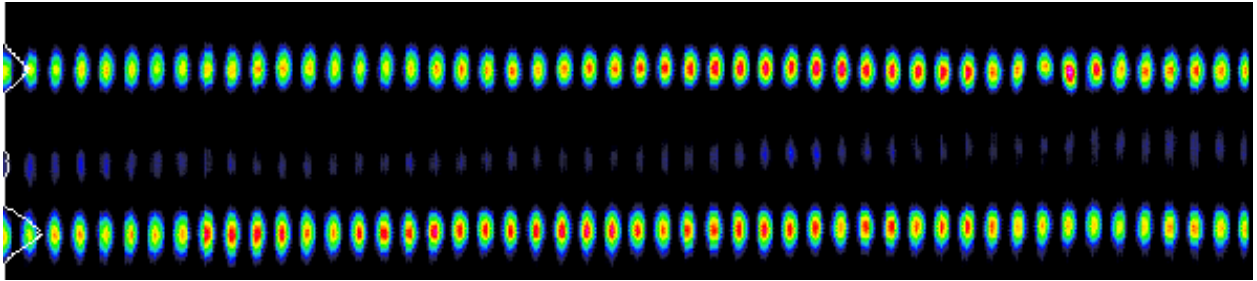
Output Array after 90 minutes (2g)

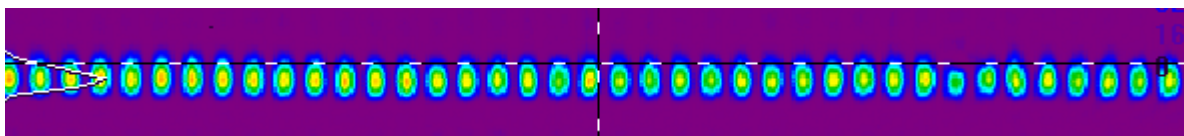**Output Array after 2.5 hours (2h)**
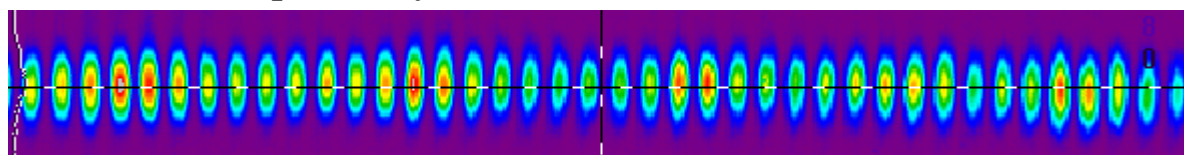

Interference of Array with Reference Beam (2i)

After a careful realignment making sure that the output beams were at the same level as the input beams we again investigated the transverse instability. Using a higher intensity, the input beam is shown in 3(a) while the output array is shown after 1 minute in 3(b). Here again after the formation of a soliton array the array split into two and then four 1-D arrays after 10 minutes (3c) and is much the same after 20 minutes (3d). Interference between the 1-D arrays and a reference beam show a 0 degree phase shift between each array (3e).
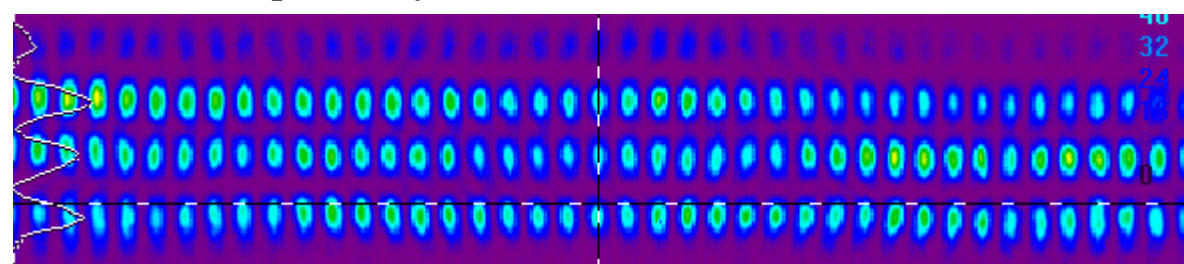
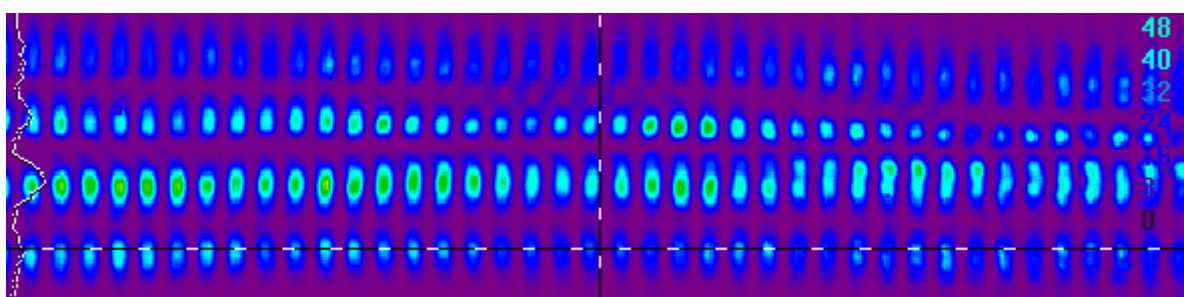**Input Array at Higher Intensity (3a)**

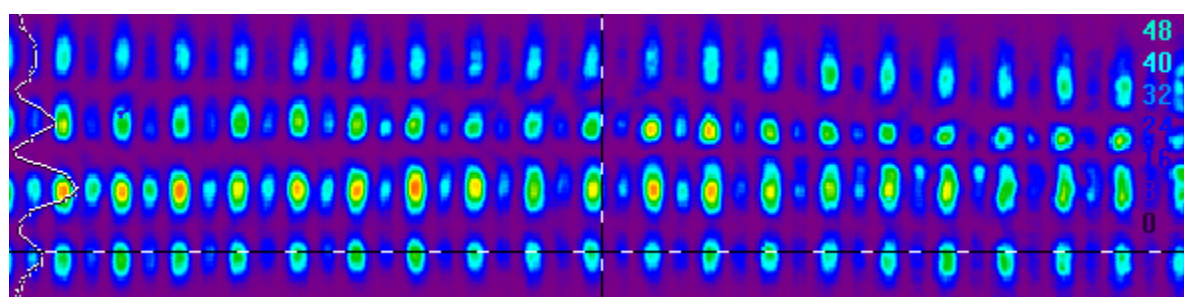**Output Array after 1 minute (3b)**

Output Array after 10 minutes (3c)

Output Array after 20 minutes (3d)

Interference of Array with Reference Beam (2e)

In conclusion, the MURI Fellow has made the first observation of a transverse instability associated with soliton array formation and has also observed discrete diffraction and modulation instability in a 1-D array. Mr. Will Black has completed his thesis and has developed a model that explains the observation of transverse instability and he is very grateful to the US Army Fellowship program for being given the opportunity to do so.

III. BIBLIOGRAPHY

IV. MANUSCRIPTS PUBLISHED UNDER THE MURI FELLOWSHIP

One paper has been submitted to Optics Letters and is currently under consideration.

V. PARTICPANTS

There were two students who worked on this project. They are: Mr. Gary Russell and Mr. Will Black at the University of Arkansas. Two years ago Mr. Russell decided to take a job at an optics company immediately after the M.S. degree and Mr. Black took over at that time.

Both students received a M.S. degree and Will Black is still working on the research toward a Ph.D. degree

VI. INVENTIONS

We have not reported or claim any inventions.

VII. TECHNOLOGY TRANSFER

We have not established a transfer of technology at the project completion.